Danaher MOTION
Engineered Systems Center

OWNER'S INSTALLATION AND OPERATING MANUAL

M4000 SERIES
DC MOTOR CONTROLLERS

FXM5
FIELD CONTROLLER

Detailed changes to software programs are introduced frequently. Please ensure this manual refers to the software version you are using.

For your safety and for proper operation, please take time to carefully read all instructions before installing and operating this unit.

LIM55416 REV D 6/01

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1
INTRODUCTION

The controller FXM5 is designed to control the field of DC motors up to 20 amps field current. The FXM5 is a single-phase, controlled-thyristor rectifier with a control logic PCB. The controlled rectifier can be configured by a selector jumper link to operate as a half-controlled or a full-controlled system.

The FXM5 may be set for different field-control modes, including automatic field weakening (constant horsepower) or constant field current, or the field can be independently controlled by an external reference. A field economy control is provided, for external switching. A field current indicator is installed on the control PCB. Drive protection is provided by a built-in-field failure relay.

The FXM5 can be used as a stand-alone unit or in conjunction with the MENTOR II DC motor variable speed drive. When used with the MENTOR II, the FXM5 is controlled by the drive, which can use various software options providing highly precise control.

THYRISTOR-CONTROLLED RECTIFIER

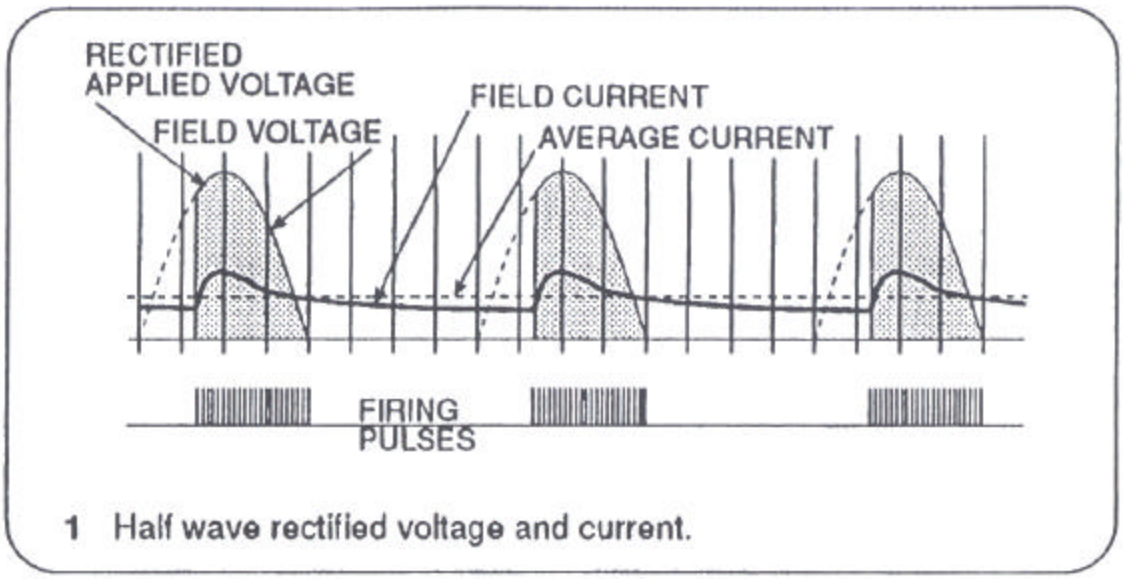
The converter consists of two SCR modules, each consisting of a pair of series-connected SCR's. The SCR modules are interconnected to form a single phase symmetrical bridge. The power circuit contains RC snubbers and transient-voltage suppressors.

Half-controlled and Full-controlled

The differences in output are illustrated in Figs. 1 and 2. In half-controlled mode, only the positive half-cycle of the AC supply voltage is able to pass. If the SCR's were fired for the full 180 degree of the half-cycle, the mean value of the output voltage would be 0.318 of the AC voltage peak amplitude. An output voltage is present, in fact, only when the SCR's are fired, so the output is controllable from zero. Fig 1 illustrates the condition when firing occurs approximately 120 degree before the voltage zero at the end of the half-cycle (this is termed '120 degree advanced').

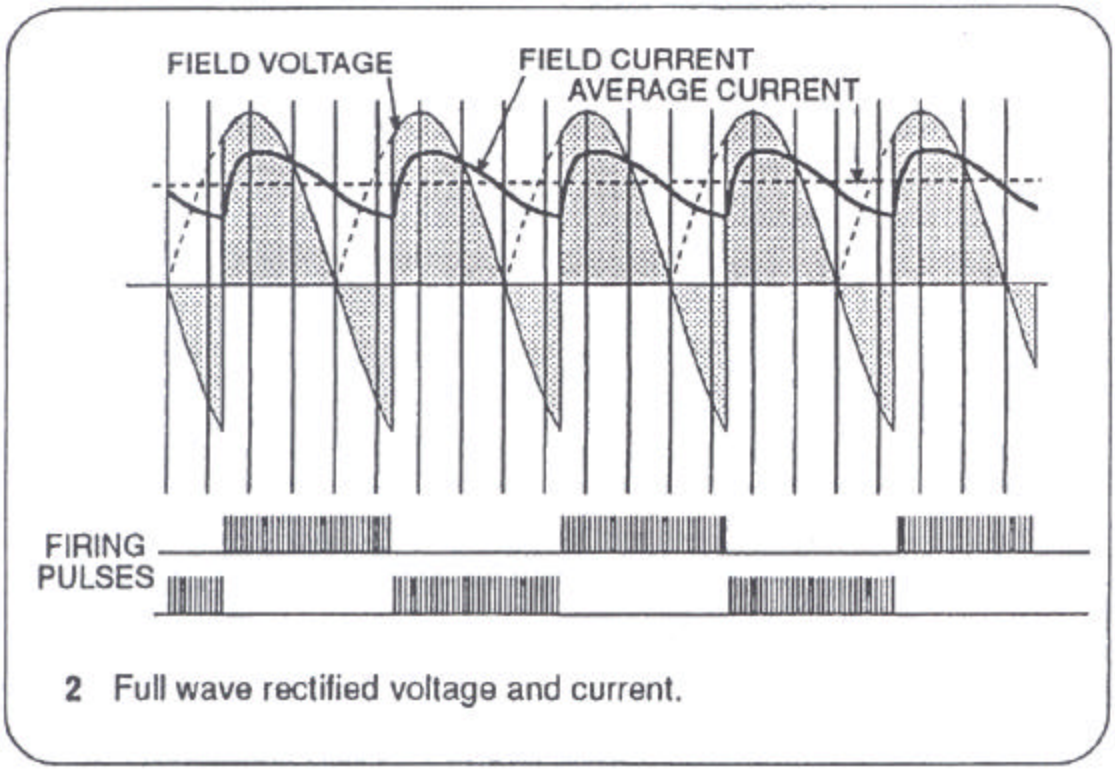
In full-controlled mode, both pairs of SCR's are in operation, fired alternately at 180 degree displacement. The maximum mean output voltage is 0.637 of the peak AC supply voltage. Fig 2 illustrates the condition when firing occurs approximately 120 degree before the voltage zero at the end of the half-cycle.

It is recommended that the field controller be used in the half-controlled mode rather than full-controlled, unless the application is one that demands that the field be capable of very rapid weakening (suppression), or if the time-constant of the motor is unusually long. In general, less current ripple is produced by a half-controlled output, and therefore torque ripple is less.



1 Half wave rectified voltage and current.

Figure 1



2 Full wave rectified voltage and current.

Figure 2

Control System

Refer to Fig.7 page 11. The control system consists of the following parts -

Voltage amplifier,
Field current amplifier,
SCR firing circuit.

The voltage amplifier senses the armature voltage and compares it with a fixed positive reference provided through a non-variable resistor. The reference is adjustable by potentiometer RV1. If the armature voltage is below the maximum value (when motor speed is below base speed), the voltage amplifier is at maximum negative causing the field current to be maximum. This condition is indicated by LED1. When LED1 is illuminated, the field current can be adjusted by potentiometer RV2.

When armature voltage reaches maximum, the output of the voltage amplifier begins to fall, weakening the field. The speed may increase further, but the armature current is progressively reduced to maintain constant-power output.

The field current is prevented from falling below a minimum value by the positive-going swing of the voltage amplifier being limited to a negative voltage. LED2 indicates that the field is at minimum. The value of the minimum field is adjusted by potentiometer RV2.

Variable field current is provided by the timing of the firing circuits of the SCR's, which is varied according to the armature voltage feedback and the adjustable potentiometer settings.

Monitoring and Protection

A field current monitor visible from the front of the module indicates by LEDs the field current as a ratio of the maximum field current setting (0.1 to 1.0, in steps of 0.2).

Internal field-failure relay changeover contacts operate when the field current falls below 0.1 of the set maximum field current. The relay can be externally connected to disconnect the motor to prevent a runaway condition.

2
SPECIFICATION

Supply Voltage
Any 50/60Hz AC voltage up to 480V.

Field Voltage
200V min. to 430V max., depending on supply voltage.

Control Voltage
Single phase AC 50HZ - 380V/440V±10%, and 220V/254V±10%
60Hz - 460V/480V±10%

Armature Voltage Feedback
220V to 600V DC. Must be protected by external fuses, max. rating 2A.

Field Current
UP to 20A, depending on configuration of output, half, or full-controlled.

Operating Temperature Range
0 degree C to 50 degree C

Storage Temperature Range
-40 C Degree to +70 Degree C

Humidity
85% maximum, non-condensing.

SCR Bridge
Single phase input, asymmetrical 2-SCR half-controlled output.
Single phase input, symmetrical 4 SCR full-controlled output.

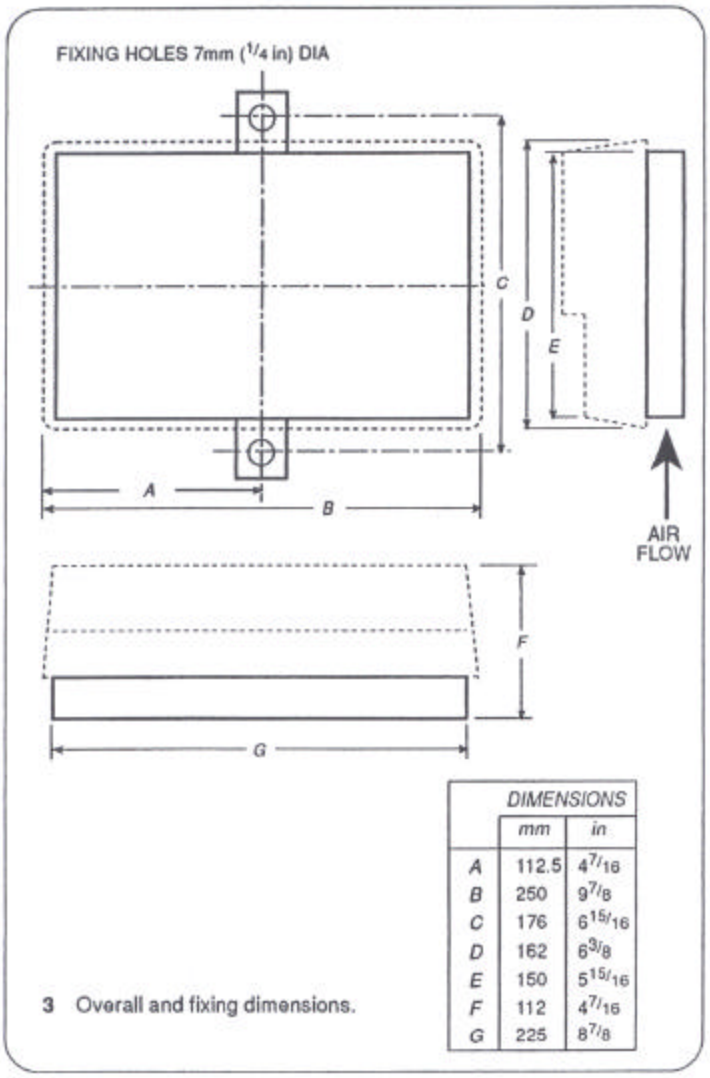
Field Failure Relay

Voltage 250V AC, 50V DC
Current 3.5A max.
Switching 1000VA max., 200W max.

3
INSTALLATION
MECHANICAL

The FXM5 module must be firmly attached to a vertical surface by the two fixing brackets, Fig.3. The module must be located so that the fins of the heat sink are vertically aligned to permit free circulation of cooling air. Access for cooling air to and from the heat sink must not be obstructed.

As supplied, the FXM5 has an integral cover, retained by four screws.



3 Overall and fixing dimensions.

	DIMENSIONS	
	mm	in
A	112.5	$4^{7}/_{16}$
B	250	$9^{7}/_{8}$
C	176	$6^{15}/_{16}$
D	162	$6^{3}/_{8}$
E	150	$5^{15}/_{16}$
F	112	$4^{7}/_{16}$
G	225	$8^{7}/_{8}$

Figure 3

4
INSTALLATION
ELECTRICAL

Safety Warning

Voltage present in the FXM5 can inflict injury and may be lethal. Persons responsible for installing and operating this equipment must be aware of the danger and take due precautions. It is recommended that the equipment SHOULD BE SAFELY ISOLATED before the cover is removed.

POWER CONNECTIONS

For voltages refer to Section 2 . A single phase AC power supply is connected to terminals L1 and L3.

Use with MENTOR II

When the FXM5 is to be operated by a MENTOR II DC drive, it is essential that terminals L1 and L3 are connected to the same phase as terminals L1 and L3 of the MENTOR II.

CONTROL CONNECTIONS

Control Voltage Range

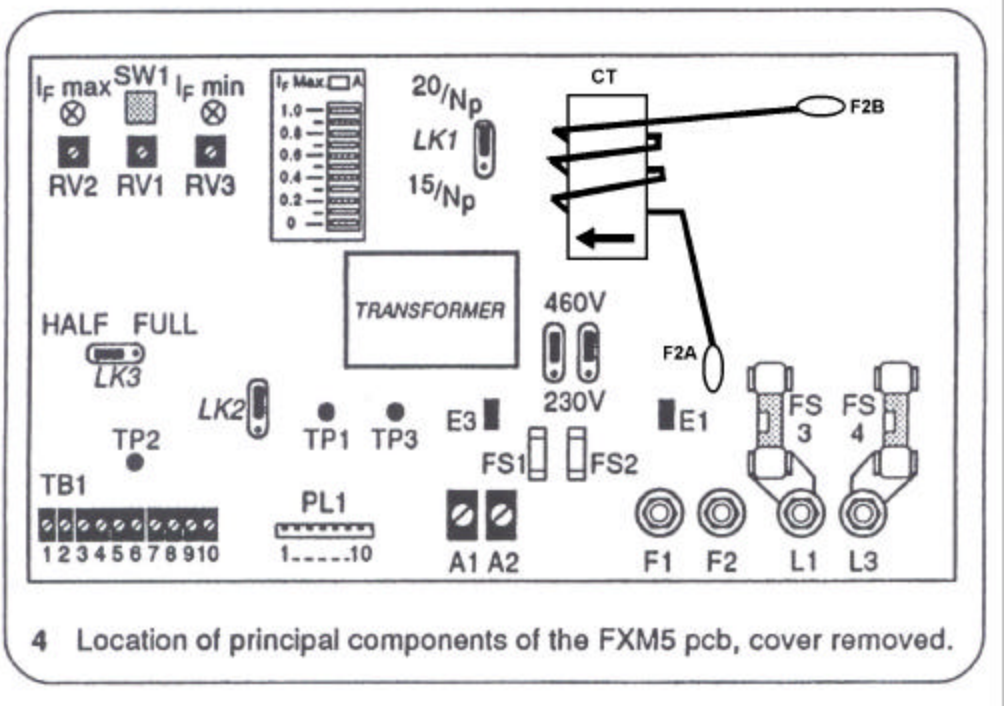
The FXM5 module must be adjusted to accept one of two 50/60Hz supply voltage ranges - either 220V to 254V $\pm$10%, or 380V to 440V $\pm$10% (up to 480V + 10% at 60Hz). The control supply must be in phase with the power supply to the SCR's.

The FXM5 PCB is adjusted for the available supply voltage range by means of TWO jumper links. These are located to the right of the transformer in the middle of the PCB, Fig.4.

A low voltage (<220V) field supply cannot be used for control supply. In this case, a separate control supply within the correct voltage range must be provided. REMOVE fuses FS1 and FS2, and connect the control supply to terminals E1 and E3 on the PCB, Fig.4.

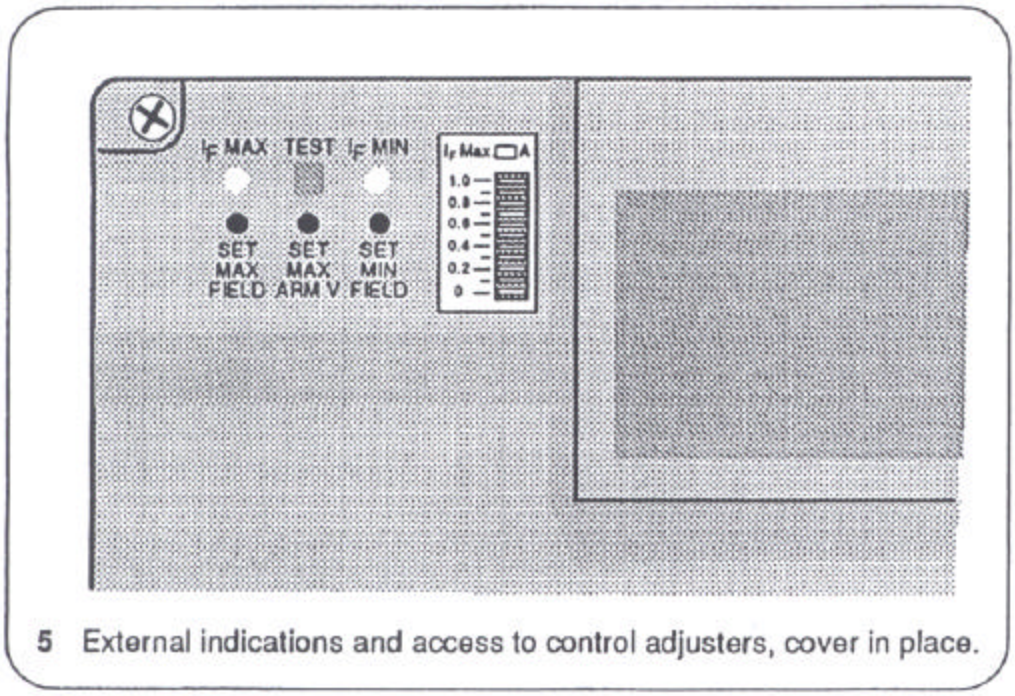
IMPORTANT

Ensure that BOTH voltage range selector jumpers are correctly set.



4 Location of principal components of the FXM5 pcb, cover removed.

Figure 4



5 External indications and access to control adjusters, cover in place.

Figure 5

FIELD CURRENT SELECTION
Stand alone operation:

The maximum field current delivered by the FXM5 is determined by the number of primary turns of the DCCT supplied with the module, and by the setting of jumper LK1.

Jumper LK1 can be placed in one of two positions, such that

$$\text{Maximum } I_f = \frac{20}{Np} \quad \text{or} \quad \frac{15}{Np}$$

where Np is the number of DCCT primary turns

The resulting max. field current can thus be adjusted to one of 20 different values as listed in the table below

DCCT Turns	Max I_f with 20/Np	Max I_f with 15/Np
10	2.0	1.5
9	2.2	1.7
8	2.5	1.9
7	2.9	2.1
6	3.3	2.5
5	4.0	3.0
4	5.0	3.6
3	6.7	5.0
2	*10.0	7.5
1	*20.0	*15.0

* When field current is greater than 9 Amps, the AC supply fuse FS3 & FS4 must be replaced with 20 Amp fuses (KTK-20), and the 20 gauge primary turns wire for the DCCT must be replaced with 14 gauge wire.

When an FXM5 is used while linked to the Mentor II with the ribbon cable, parameter 06.11, DCCT turns and LK1 jumper position should be adjusted per the following table:

Maximum current (A)	Primary turns Np	LK1 jumper position		Parameter 06.11
		20/Np	15/Np	
1	10		X	1
2	10	X		2
3	5		X	3
4	5	X		4
5	4	X		5
6	3	X		6
7	2	X		7
8	2	X		8
9	2	X		9
10*	2	X		10
11*	1		X	11
12*	1		X	12
13*	1		X	13
14*	1		X	14
15*	1		X	15
16*	1	X		16
17*	1	X		17
18*	1	X		18
19*	1	X		19
20*	1	X		20

* When field current is greater than 9 Amps, the AC supply fuse FS3 & FS4 must be replaced with 20 Amp fuses (KTK-20), and the 20 gauge primary turns wire for the DCCT must be replaced with 14 gauge wire.

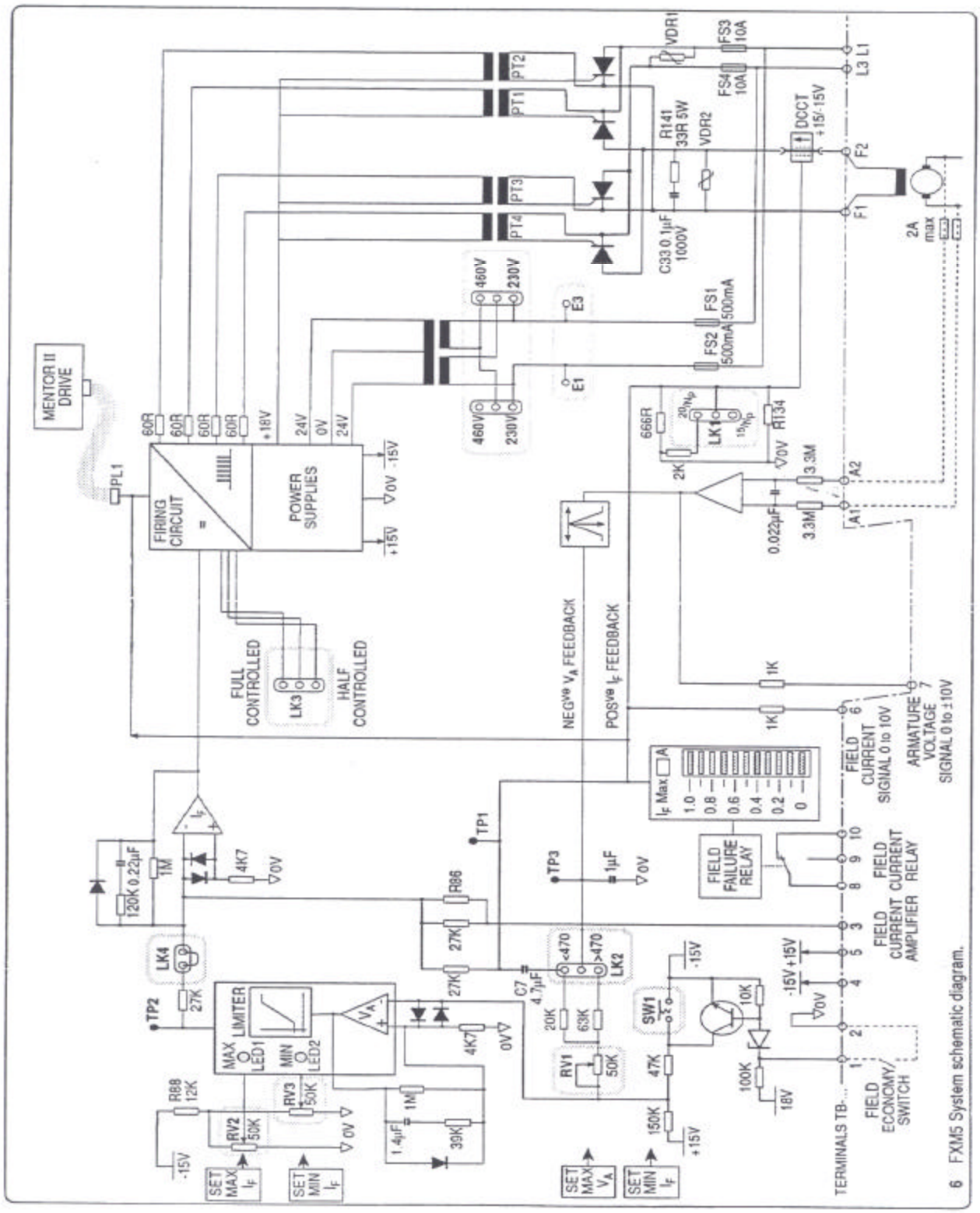

MENTOR II DRIVE
PL1
FIRING CIRCUIT
POWER SUPPLIES
FULL CONTROLLED
HALF CONTROLLED
LK3
NEG^ve V_A FEEDBACK
POS^ve I_F FEEDBACK
PT1
PT2
PT3
PT4
VDR1
VDR2
R141 33R 5W
C33 0.1µF 1000V
FS1 500mA
FS2 500mA
FS3 10A
FS4 10A
DCCT +15/-15V
L3 L1
F1
F2
2A max
460V
230V
E1
E3
666R
2K
LK1
RT34
3.3M
0.022µF
A1
A2
1K
ARMATURE VOLTAGE SIGNAL 0 to ±10V
FIELD CURRENT SIGNAL 0 to 10V
I_F Max
FIELD FAILURE RELAY
FIELD CURRENT RELAY
FIELD CURRENT AMPLIFIER
FIELD ECONOMY/ SWITCH
TERMINALS TB...
LK4
LK2
TP1
TP2
TP3
R86
R88 12K
RV1 50K
RV2 50K
RV3 50K
SW1
C7 4.7µF
MAX LIMITER
MIN
LED1
LED2
SET MAX I_F
SET MIN I_F
SET MAX V_A
SET MIN I_F
6 FXM5 System schematic diagram.

Figure 6

Protective Fuses
Note that the field output circuit is protected by 10A fuses as standard (FS3 and FS4, Fig.4). If a field current in excess of 9A is required the fuses must be replaced by HRC fuses of appropriate rating.

ARMATURE VOLTAGE FEEDBACK RANGE
Refer to Fig.4 page 7 and Fig. 7 page 11.
Provision is made to accept voltage feedback over a wide range. If the voltage is above 470V additional resistance must be inserted in the circuit. Adjustment is made by jumper LK2.

CONFIGURATION
Automatic Field Weakening (Constant Power) Refer to Fig.8.

In this configuration, the armature voltage Va is increased to a maximum with a fixed field current I_f to provide constant torque up to base speed. Further increase of speed results in the field being weakened, providing constant power output.

For a DC motor: Power(W) = Armature Voltage x Armature Current

$$\text{Speed(n)} = \text{Constant} \times \frac{\text{Armature Voltage}}{\text{Field Current}}$$

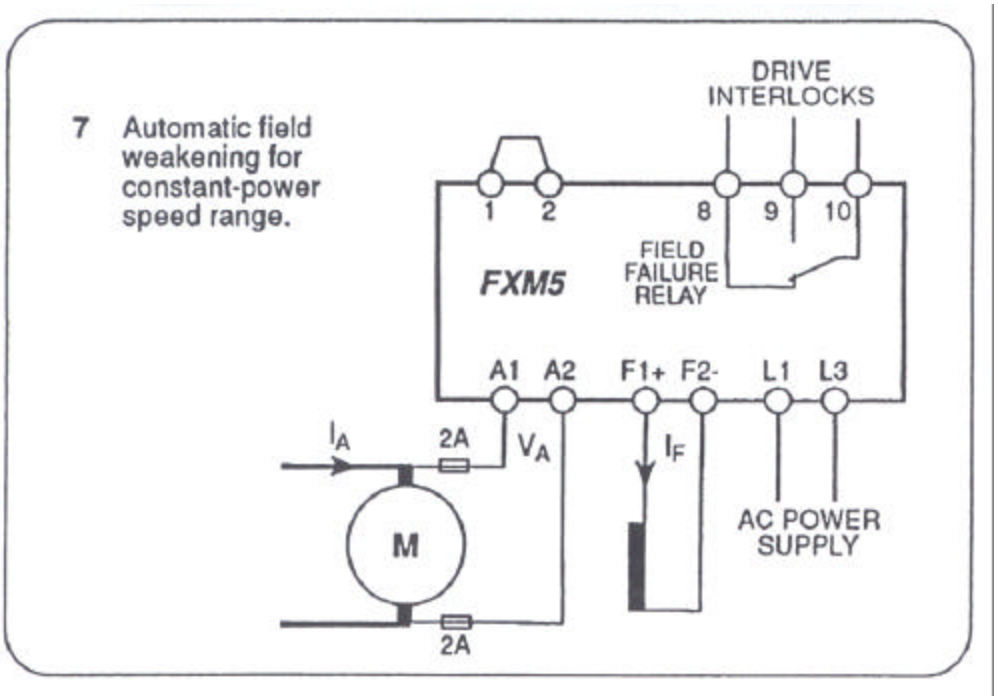


Figure 7

Constant Field Current Refer to Fig. 8.
In this configuration, field current is stabilized to be independent of variations in both supply voltage and ambient temperature.

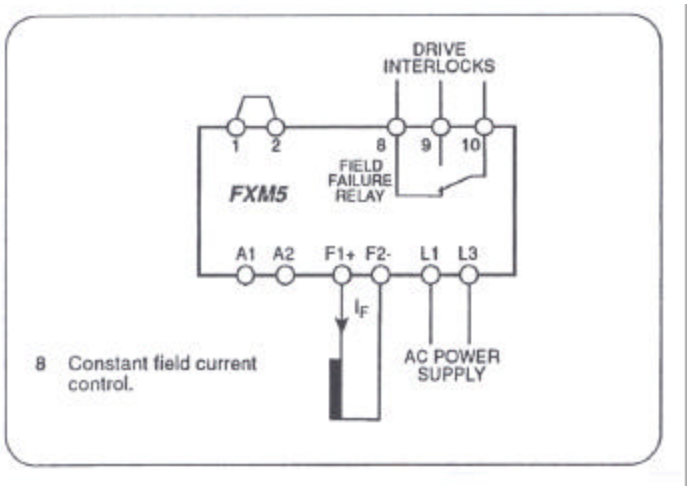


Figure 8

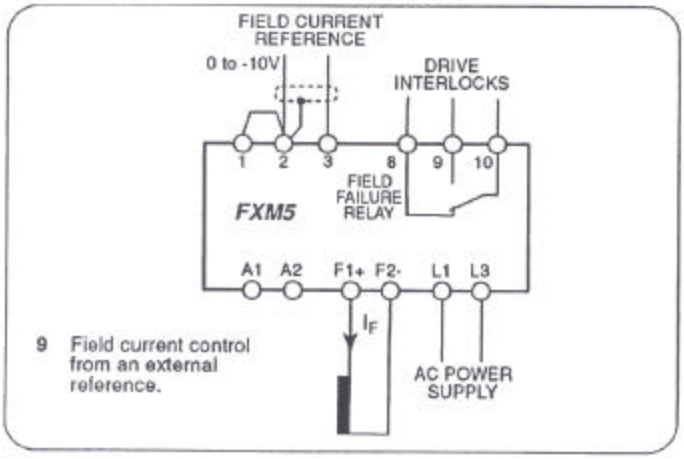


Figure 9

Control by external reference Refer to Fig. 9.
Applications for this mode include load-sharing and coiler/uncoiler operation. The field current is controlled by a OV to - 10V reference applied to TB1-3.

Field Economy

Refer to Fig. 7 page 11.

Under normal operating conditions, terminals TB1-1 and TB-2 are connected as shown in Figs. 7, 8 and 9. By breaking this connection, the field current is set to its minimum value. This may be necessary to prevent overheating of non-ventilated motors when stationary, and may be used to maintain a small current in the windings of motors installed in humid environments to prevent condensation.

ADJUSTMENTS

Refer to Fig. 4 page 7 and Fig. 7 page 11.

Armature Voltage Feedback

Adjust jumper link LK2 according to whether the feedback voltage exceeds 470V or otherwise.

Maximum Armature Voltage

To set potentiometer RV1. When the drive is to operate in field-weakening mode (constant power above base speed) RV1 sets the armature voltage, and hence the speed, above which the field begins to weaken. The potentiometer is set with the motor running, as follows-

Turn RV1 fully clockwise
Run the drive up to full speed
Adjust RV1 so that the armature voltage corresponds to the maximum rated value.

Maximum Field Current

To set potentiometer RV2. The MAX I_f monitor corresponds to fully-clockwise rotation of the potentiometer. Should a lower maximum If be required, turn RV2 counter-clockwise.

Minimum Field Current

To set potentiometer RV3. This control should be adjusted only when LED2 (MIN I_f) is illuminated. To achieve this, press switch SW1 and hold whilst adjusting RV3.

Minimum field current can be adjusted within the range 0.1 to 0.9 times maximum I_f, as indicated by the monitor. Minimum field current should be set just below the actual minimum working field current of the motor. If adjusted to less that 0.1 X I_f, the field failure relay will de-energize.

5
DIAGNOSTICS

FAULT	*POSSIBLE CAUSE*	*ACTION*
Main contactor does not close.	Field failure relay RL1 is de-energized.	Check fuses FS1,2 3 and 4.
Field current monitor		Check field connections. Check that RV3 is not turned fully counter-clockwise.
Motor will not run up to maximum speed.	Max armature voltage feedback.	Adjust max armature voltage RV1.
Field current monitor stays at maximum.	Max armature voltage feedback.	Check fuses in supply to terminals A1 and A2.
Drive lacks torque and/or field failure relay RL1 trips at high speed.	Maximum armature voltage set too low.	Adjust max. armature voltage RV1.
Overload trip when motor is normally-loaded.	Max. field current set too low.	Adjust max. field current RV2.
Field failure relay trips when motor is under rapid acceleration.	Max. field current set too low.	Adjust min. field current RV3.

Figure 10 Ribbon cable connection between Mentor II drive and FXM-5 field controller.